APPENDIX B

THE REMI MODEL

Introduction
Framework of the REMI Model
Economic Geography Linkage
Assumptions of the REMI Model
Verification of the Model
Enhancements to the Model

INTRODUCTION

In an effort to expand socioeconomic impact assessments for proposed rules and AQMP revisions, the District has been using a computerized economic model from Regional Economic Models, Inc. (REMI) to assess the socioeconomic impacts on the four-county economy since 1990. The REMI covers the geographic area within the counties of Los Angeles, Orange, Riverside, and San Bernardino. The structure and assumptions of the model are briefly described below.

FRAMEWORK OF THE REMI MODEL

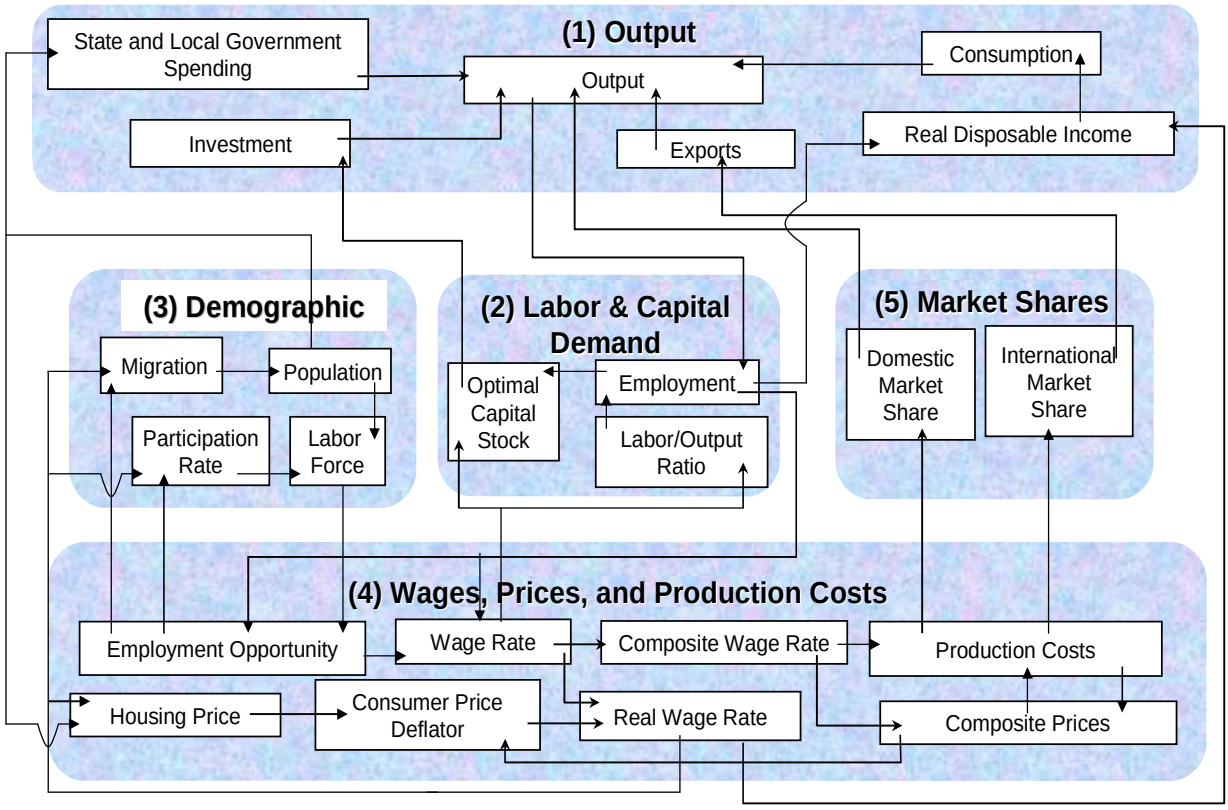
The District's REMI model links the economic activities in the counties of Los Angeles, Orange, Riverside, and San Bernardino. The model used for the draft final 2007 AQMP assessment is unique in that each county is further divided to account for the politically, socially, economically, and geographically diversified structure of Southern California economy. There are 11 sub-county regions in Los Angeles County, four in Orange County, two in Riverside County, and two in San Bernardino County. The divisions of the sub-regions were originally developed in 1996 and have been updated to reflect the 2000 Census.

The REMI model for each sub-region is comprised of a five block structure that includes (1) output and demand, (2) labor and capital, (3) population and labor force, (4) wages, prices and costs, and (5) market shares. These five blocks are interrelated and the linkages are shown in Figure B-1. Each block is built upon a two-step process. First, producers and consumers throughout all regions of the country have similar behavioral characteristics. Because of these similarities, statistical techniques are used to estimate economic responses based on studies performed throughout the United States. The second step of the modeling process is region specific, and involves calibration of the model based on region-specific historical data.

The standard structure has 66 private non-farm industries (3-digit NAICS), three government sectors and a farm sector, 94 occupations, and 22 final demand sectors. The demographic/migration component captures population changes due to births, deaths, migration, and changes to special population (e.g., prisoners and college students); and has 160 ages/gender/race/ethnicity cohorts. The input-output module contains detailed inter-industry relationships for 198 sectors and is used to assess the detailed inter-industry effect of a policy change. Results from the input-output module are fed through population, price and economic geography equations to produce a complete economic and demographic assessment.

FIGURE B-1

Components of REMI Model

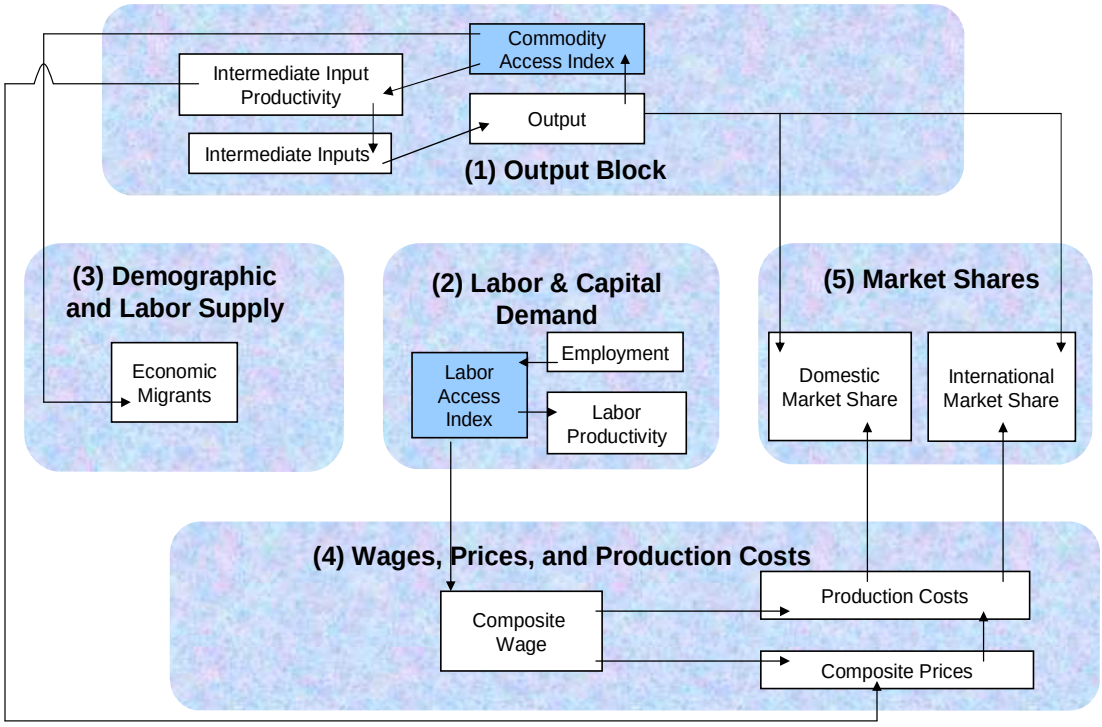


ECONOMIC GEOGRAPHY LINKAGE

The economic geography module (Figure B-2) explains dispersion and agglomeration effects among competing factors in urban and regional economics through two indexes in the model. The commodity index assesses the impact of increased access to intermediate inputs on increased productivity and thus a reduction in production cost. Consumers would benefit as well due to the increased access to goods and services. The labor index captures the positive impact on labor productivity and cost as access to labor with a mix of skills expands. As land price rises and congestion sets in, economic activities tend to disperse.

FIGURE B-2

Economic Geography Linkage



ASSUMPTIONS OF THE REMI MODEL

The REMI model has been built based on well-established economic theory and is updated regularly to incorporate new findings in economic theory and new historical data. Major assumptions behind the REMI model fall into the following three categories: overall, production, and population and labor. The major assumptions behind the REMI model are as follows.

Overall

1. Production costs, such as capital equipment, labor and fuel, are allowed to be substituted based on the changes in relative costs of these inputs to those in the United States. Total production costs are the sum of input costs weighted by their usage.

2. Location of a firm is driven by profitability.

3. All industries sell to both local and national markets. The model calculates the proportions of local demand that an industry can satisfy and its export share. Exports are divided into shipments from one sub-county region to the remaining regions (19 regions altogether) and sales outside of the four counties (Los Angeles, Orange, Riverside, and San Bernardino).

4. The economic geography module accounts for productivity and corresponding price effects due to access to labor and other production inputs. The labor access index (Block 2 in Figure B-2) as well as the nominal wage rate determines the composite wage rate, which, in turn, affects the cost of production along with prices of other inputs. The delivered price of a good or service is based on the cost of the commodity at the production site and the cost of delivering the commodity to the destination place. This price weights the delivered prices from all locations that ship to the home region and is calculated relative to the delivered prices in all other regions.

5. The REMI model consists of exogenous and endogenous economic variables. Values of exogenous variables are determined outside of the model. Exogenous variables are a driving force of change in the regional economy. The resulting changes are reflected in the values of endogenous variables calculated by the model. Therefore, policy changes can be simulated by changing exogenous variables whose values are developed by AQMD staff as input to the REMI model. For example, increases in demand for control equipment due to a rule can be simulated by increasing the sales of the supplier of control equipment. The impact of such a policy change includes changes in employment, among others.

6. There will be two avenues for market expansion. First, as the cost of production decreases, firms become more competitive in the export market and more competitive with imports. Second, markets are assumed to expand as a region's economy grows.

Production

1. Production costs affect regional competitiveness which impacts the shares of local and export markets. As the relative production costs increase, there will be a reduction in the proportion of local demand which can be satisfied locally as imported goods are substituted for local goods.

2. Production levels drive labor demand which interacts with labor supply to determine wage rates. Combined with other production costs, e.g., capital and fuel costs, wages determine relative production costs in the four-county region compared to the rest of the United States.

3. Production levels are determined by the total demand which consists of consumption, investment, government spending, and net exports. Employment is determined by the level of production and labor intensity, i.e., number of employees per unit of production.

4. An increase in demand will increase production by a factor greater than one because of indirect impacts.

Population and Labor

1. There are four types of migrants: international migrants, retired migrants, former military personnel, and economic migrants. These economic migrants are individuals moving to the region for employment opportunities. They respond to both economic and amenity factors.

2. The demographic section of the model predicts the number of births and deaths that occur in the population. Labor supply is derived from the indigenous labor force and potential job migrants.

3. Labor is segmented by occupation as well as by industry. Employment within an industry is translated to occupation level employment through the use of occupational skill requirements by industry.

VERIFICATION OF THE MODEL

The REMI model for the Southern California geography was independently evaluated by the University of Pittsburgh in 1989 to determine its forecasting and simulation capabilities. The model's performance was judged to meet accepted standards of practice (Cassing and Giarratani, 1992).

ENHANCEMENTS TO THE MODEL

The District's socioeconomic assessment process is an evolving one. The assessment has expanded from impacts on directly affected industries to include employment impacts on all industries with the use of the REMI model. In 1992, enhancements were made to the REMI model to allow the assessment of impacts on different income groups and on low- versus high-wage groups.

Using the nationwide median weekly earnings of full-time workers from the 2003 Bureau of Labor Statistics (BLS) Current Population Survey (CPS), 94 occupations in the REMI model were ranked in ascending order of earnings and divided into five equal (quintile) groups. Table B-1 shows how the 94 civilian occupations were ranked.

TABLE B-1

Ranking of Occupational Earnings

Occupation	Median Weekly Earnings	Quintile Group
Other food preparation and serving related workers	$321	1
Cooks and food preparation workers	$334	1
Food and beverage serving workers	$335	1
Textile, apparel, and furnishings occupations	$344	1
Other education, training, and library occupations	$351	1
Other personal care and service workers	$351	1
Supervisors, farming, fishing, and forestry workers	$369	1
Agricultural workers	$369	1
Fishing and hunting workers	$369	1
Forest, conservation, and logging workers	$369	1
Nursing, psychiatric, and home health aides	$377	1
Personal appearance workers	$390	1
Animal care and service workers	$391	1
Funeral service workers	$391	1
Grounds maintenance workers	$395	1
Building cleaning and pest control workers	$402	1
Supervisors, food preparation and serving workers	$413	1
Helpers, construction trades	$420	1
Food processing occupations	$421	1
Assemblers and fabricators	$440	2
Other protective service workers	$445	2
Entertainment attendants and related workers	$446	2
Information and record clerks	$449	2
Woodworkers	$452	2
Material moving occupations	$464	2
Supervisors, building, grounds cleaning maintenance workers	$469	2
Supervisors, personal care and service workers	$472	2
Retail sales workers	$488	2
Other healthcare support occupations	$492	2
Other office and administrative support workers	$502	2
Communications equipment operators	$508	2
Financial clerks	$515	2
Other transportation workers	$520	2
Secretaries and administrative assistants	$532	2
Material recording, scheduling, dispatching, distributing occupations	$551	2
Other production occupations	$571	2
Other healthcare practitioners and technical occupations	$587	2
Transportation, tourism, and lodging attendants	$587	2

TABLE B-1 (Continued)

Occupation	Median Weekly Earnings	Quintile Group
Printing occupations	$594	3
Construction trades and related workers	$599	3
Other construction and related workers	$599	3
Extraction workers	$599	3
Motor vehicle operators	$603	3
Vehicle and mobile equipment mechanics, installers, repairers	$606	3
Supervisors, sales workers	$611	3
Metal workers and plastic workers	$616	3
All other counselors, social, and religious workers	$647	3
Supervisors, office and administrative support workers	$650	3
Water transportation occupations	$653	3
Entertainers and performers, sports and related occupations	$661	3
Counselors, social workers, other community, social service specialists	$666	3
Other teachers and instructors	$681	3
Other installation, maintenance, and repair occupations	$686	3
Supervisors, production workers	$693	3
Other sales and related workers	$695	3
Legal support workers	$696	3
Supervisors, transportation and material moving workers	$705	4
Plant and system operators	$711	4
Art and design occupations	$727	4
Media and communication occupations	$733	4
Health technologists and technicians	$751	4
Religious workers	$761	4
Law enforcement workers	$764	4
Primary, secondary, and special education teachers	$767	4
Electrical/electronic equipment mechanics, installers, repairers	$786	4
Drafters, engineering, and mapping technicians	$792	4
Librarians, curators, and archivists	$797	4
Supervisors, construction and extraction workers	$810	4
Fire fighting and prevention workers	$816	4
Life, physical, and social science technicians	$818	4
Sales representatives, services	$826	4
Supervisors of installation, maintenance, and repair workers	$832	4
Social scientists and related occupations	$838	4
Business operations specialists	$842	4
Financial specialists	$842	4
Media and communication equipment occupations	$845	4
Rail transportation occupations	$884	5
Sales representatives, wholesale and manufacturing	$885	5

TABLE B-1 (Continued)

Occupation	Median Weekly Earnings	Quintile Group
Life scientists	$891	5
Occupational and physical therapist assistants and aides	$892	5
Health diagnosing and treating practitioners	$899	5
First-line supervisors/managers, protective service workers	$904	5
Physical scientists	$948	5
Postsecondary teachers	$982	5
Architects, surveyors, and cartographers	$1,013	5
Other management occupations	$1,023	5
Computer specialists	$1,049	5
Mathematical science occupations	$1,049	5
Engineers	$1,053	5
Advertising, marketing, promotions, public relations, sales managers	$1,127	5
Operations specialties managers	$1,136	5
Air transportation occupations	$1,350	5
Top executives	$1,558	5
Lawyers, judges, and related workers	$1,560	5

The percentage changes of a policy on each quintile of earnings can thus be reported for occupational wage rate, employment, and wage bill.

The ES-202 data (excluding self-employment) from the BLS for the four-county area provides the average annual wage per worker (full-time and part-time) for the 66 private non-farm industries in the REMI model. By ranking the 66 industries in ascending order of the average annual wage per worker, we can divide them into five equal groups, as shown in Table B-2:

TABLE B-2

Ranking of Wages by Sector

Sector	Average Annual Wage	Quintile Group
Private households	$7,957	1
Forestry and Logging; Fishing, Hunting	$13,565	1
Real estate	$13,941	1
Social assistance	$16,350	1
Food services, drinking places	$16,847	1
Personal, laundry services	$16,858	1
Agriculture	$18,632	1

TABLE B-2 (CONTINUED)

Sector	Average Annual Wage	Quintile Group
Transit, ground passenger transportation	$20,929	1
Repair and maintenance	$21,227	1
Administrative and support services	$22,766	1
Nursing and residential care facilities	$26,439	1
Accommodation	$26,552	1
Apparel mfg	$27,212	1
Retail trade	$27,239	2
Leather and, allied product mfg	$27,305	2
Educational services	$27,398	2
Amusement, gambling, and recreation	$28,958	2
Truck transportation, couriers and messengers	$30,701	2
Membership association and organization	$30,771	2
Textile product mills	$31,709	2
Performing arts and spectator sports	$32,511	2
Textile mills	$32,679	2
Rental and leasing services	$34,190	2
Furniture and related prod mfg	$35,338	2
Construction	$37,848	2
Wood product mfg	$37,965	2
Printing and related supporting activities	$40,676	3
Plastics and rubber prod mfg	$41,136	3
Ambulatory health care services	$42,002	3
Warehousing and storage	$43,362	3
Food mfg	$43,492	3
Professional and technical services	$45,190	3
Waste management and remedial services	$46,769	3
Fabricated metal product mfg	$45,656	3
Nonmetallic mineral product mfg	$46,953	3
Securities commodity contracts, and investment	$48,891	3
Scenic and sightseeing transportation	$49,993	3
Primary metal mfg	$50,080	3
Electrical equipment and appliance mfg	$50,082	3
Museums, historical sites, zoos, and parks	$50,789	4
Miscellaneous mfg	$51,794	4
Wholesale trade	$53,717	4
Hospitals	$56,461	4
Paper mfg	$57,716	4
Beverage and tobacco product mfg	$59,324	4
Insurance carriers and related activities	$60,925	4
Support activities for mining	$64,078	4

TABLE B-2 (CONTINUED)

Sector	Average Annual Wage	Quintile Group
Air transportation	$64,557	4
Machinery mfg	$64,825	4
Motor vehicle mfg	$65,440	4
Oil, gas extraction	$65,996	4
Publishing industries, except Internet	$66,913	4
Monetary authorities	$68,876	5
Management of companies and enterprises (55)	$68,979	5
Mining (except oil, gas)	$69,619	5
Water transportation	$71,624	5
Internet services and data processing	$72,067	5
Broadcasting, except Internet; telecommunication	$75,422	5
Motion picture and sound recording industries	$77,208	5
Chemical mfg	$83,656	5
Transport equipment. mfg. Excl. motor vehicle	$86,719	5
Rail transportation	$89,052	5
Computer and electronic product mfg.	$90,112	5
Utilities	$90,431	5
Pipeline transportation	$93,561	5
Petroleum and coal products mfg.	$149,700	5

The percentage change in employment, wage bill, and wage rate resulting from a policy can thus be reported for each quintile of wages, by sector.

The annual Consumer Expenditure Survey (CEX 2005), published by the BLS, provides a continuous flow of information on the buying habits of American households. The CEX reports average annual expenditures and characteristics of households by income group. There are five income groups: from the households earning the top 20 percent of income to those earning the bottom 20 percent of income.

By linking consumption expenditures in the REMI model with spending patterns of the eight income groups in the CEX, we can then develop a composite price change for consumer goods for each income group.

In 1996, the REMI model for the South Coast economy had expanded from a county-based model with four counties to a sub-county model with 19 sub-county regions as Los Angeles and Orange Counties have grown denser and Riverside and San Bernardino Counties have sprawled to accommodate economic migrants. The 19 sub-region geography provided opportunities for the integration of economic and air quality data, resulting in a more balanced outlook of socioeconomic impacts of public policy.